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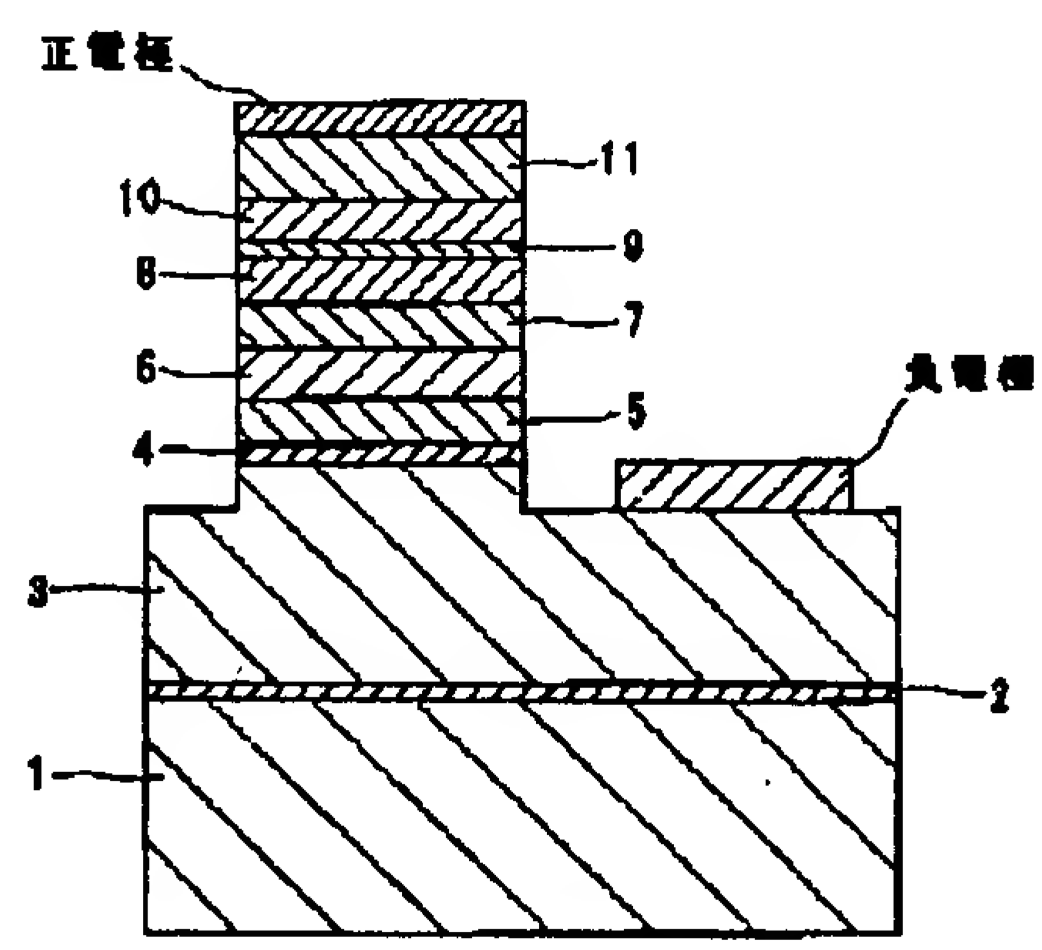
(54) **NITRIDE SEMICONDUCTOR LIGHT EMITTING ELEMENT**

(57) Abstract:

PROBLEM TO BE SOLVED: To improve light emission output of a light emitting element, by forming an active layer of multiple quantum well structure wherein well layers composed of nitride semiconductor containing In and barrier layers composed of nitride semiconductor containg In are laminated.

SOLUTION: A buffer layer 2, an N-type contact layer 3, a first N-type layer 4 acting as a buffer layer, a second N-type layer 5 acting as a light confining layer, and a third N-type layer 6 acting as a guide layer are formed on a sapphire substrate 1. An active layer 7 composed of multiple quantum well structure is formed by alternately laminating a plurality of well layers composed of undoped InGaN and a plurality of barrier layers composed of undoped InGaN. A first P-type layer 8 acting as a cap layer, a second P-type layer 9 acting as a light guide layer, and a third P-type layer 10 acting as a light confining layer are formed. A P-type contact layer 11 is formed, selective etching is performed, the surface of the N-type contact layer is exposed, and a positive electrode and a negative electrode are formed.



[Claim(s)]

[Claim 1] The nitride semi-conductor light emitting device characterized by having the barrier layer of the multiplex quantum well structure where the laminating of the well layer which consists of a nitride semi-conductor containing In, and the barrier layer which consists of a nitride semi-conductor containing In was carried out.

[Claim 2] The nitride semiconductor laser component according to claim 1 or 1 characterized by for the thickness of said well layer being 70A or less, and the thickness of said barrier layer being 150A or less.

[Claim 3] The nitride semiconductor laser component according to claim 1 or 2 characterized by p mold cladding layer of 1 micrometer or less of thickness which consists of a p mold nitride semi-conductor which contains aluminum in said barrier layer at least having touched.

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the light emitting device which consists of a nitride semi-conductor (InXAlYGa1-X-YN, 0 <=X, 0<=Y, X+Y<=1) used for light emitting diode (LED), a laser diode (LD), etc.

[0002]

[Description of the Prior Art] Epitaxial growth of the nitride semi-conductor shown by InXAlYGa1-X-YN (0 <=X, 0<=Y, X+Y<=1) is carried out on the substrate using vapor growth, such as MOVPE (metal-organic chemical vapor deposition), MBE (molecular-beam beam vapor growth), and HDVPE (halide vapor growth). moreover, since this semiconductor material is the extensive wide gap semi-conductor of a direct transition mold, it is got to know as an ingredient of the light emitting device from ultraviolet to red -- having -- **** -- recently -- this ingredient -- high -- brightness blue LED and green LED are realized and implementation of a laser diode (LD) is desired as a following target.

[0003] As a light emitting device using a nitride semi-conductor, the LED component is shown in JP,6-21511,A. The LED component equipped with the barrier layer of the multiplex quantum well structure which carried out the laminating of the well layer of

100A of thickness which consists of InGaN, and the 100A barrier layer of thickness which consists of GaN is shown by this official report.

[0004]

[Problem(s) to be Solved by the Invention] According to said official report, the LED component which has terrorism structure to the double of separation ****** type which sandwiched the barrier layer of the multiplex quantum well structure which consists of InGaN and GaN by the cladding layer which consists of GaN and AlGaN is shown. By making a barrier layer into multiplex quantum well structure, the LED component excellent in the radiant power output can be obtained. However, it is necessary to heighten a radiant power output further rather than LED in LD. Therefore, this invention is accomplished in view of such a situation, the place made into the purpose is to heighten the radiant power output of the light emitting device which consists of a nitride semi-conductor, and realize semiconductor laser, and a high power light emitting device is realized by improving especially the structure of a barrier layer.

[0005]

[Means for Solving the Problem] The light emitting device of this invention is characterized by having the barrier layer of the multiplex quantum well structure where the laminating of the well layer which consists of a nitride semi-conductor containing In, and the barrier layer which consists of a nitride semi-conductor containing In was carried out.

[0006] In the barrier layer which has multiplex quantum well structure, it is characterized by for the thickness of a well layer being 70A or less, and the thickness of a barrier layer being 150A or less.

[0007] Furthermore, the light emitting device of this invention is characterized by p mold cladding layer of 1 micrometer or less of thickness which consists of a p mold nitride semi-conductor which contains aluminum in a barrier layer at least having touched.

[0008] In the light emitting device of this invention, in the well layer which consists of a nitride semi-conductor containing In which constitutes multiplex quantum well structure (MQW:Multi-quantum-well), $In_XGa_{1-X}N$ ($0< X<=1$) of 3 yuan mixed crystal is desirable, and $In_YGa_{1-Y}N$ ($0< Y<1$) of a barrier layer of 3 yuan mixed crystal is desirable similarly in it. Since the object with sufficient crystallinity of 4 yuan of 3 yuan is obtained compared

with the thing of mixed crystal, the radiant power output of InGaN of mixed crystal improves. Moreover, a barrier layer makes bandgap energy larger than a well layer, and is well + obstruction + well +... A laminating is carried out and multiplex quantum well structure is constituted so that it may become a + obstruction + well layer. Thus, if a barrier layer is set to MQW which carried out the laminating of the InGaN, high power LD for about 365nm - 660nm is realizable by luminescence between quantum level.

[0009] When realizing LD, as for the thickness of a barrier layer, i.e., the total thickness of the barrier layer which carried out the laminating of a well layer and the barrier layer, adjusting to 200A or more is desirable. When thinner than 200A, an output is not fully improved but it is in the inclination which cannot carry out laser oscillation easily. Moreover, it is desirable to be in the inclination for an output to decline, when the thickness of a barrier layer is also too thick, and to adjust to 0.5 micrometers or less.

[0010] As for the thickness of a well layer, adjusting to 50A or less is still more desirable still more desirably 70A or less. Drawing 2 is drawing showing the relation between the thickness of a well layer, and a radiant power output, and the radiant power output shows the LED component. About an output, it can say that it is the same also at LD. This shows that this thickness is below the critical thickness of an InGaN well layer. At InGaN, electronic Bohr radius is about 30A, and, for this reason, the quantum effectiveness of InGaN shows up in 70A or less.

[0011] Moreover, it is desirable to also adjust still more desirably 150A or less also of thickness of a barrier layer to the thickness of 100A or less. Although drawing 3 is drawing showing the relation between a barrier layer, thickness, and a radiant power output and a radiant power output shows an LED component like drawing 2 , the same thing can be said also about LD.

[0012] next, the nitride semi-conductor of p mold which contains aluminum at least in contact with a barrier layer in the light emitting device of this invention -- desirable -- 3 yuan mixed crystal or duality -- it is desirable to form p mold cladding layer which consists of AlZGa1-ZN (0< Z<=1) of mixed crystal. Furthermore, 1 micrometer or less of this AlGaN is adjusted to 10A or more and 0.5 micrometers or less still more preferably. by forming this p mold cladding layer in contact with a barrier layer, the output of a

component is markedly alike and improves. Conversely, if the cladding layer which touches a barrier layer is set to GaN, the output of a component will fall to 3 by about 1/. The detailed thing is unknown although it guesses because there is an operation which suppresses that AlGaN tends to become p mold compared with GaN, and InGaN decomposes this at the time of p mold cladding layer growth. Moreover, it is because it is in the inclination for a crack to become easy to go into the cladding layer itself, and for component production to become difficult when the thickness of p mold cladding layer is thicker than 1 micrometer.

[0013]

[Function] The light emitting device of this invention is the multiplex quantum well structure which carried out the laminating of the well layer which a barrier layer turns into from InGaN, and the barrier layer which consists of InGaN with a larger band gap than a well layer. It differs in that the barrier layer of JP,6-21511,A is GaN. In MQW to which this carried out the laminating of the well layer and barrier layer of a thin film, the stress concerning each class is different. When the laminating of the barrier layer which consists of InGaN on a well layer like this invention is carried out, the barrier layer which consists of InGaN has a soft crystal compared with GaN and an AlGaN crystal. Therefore, since thickness of AlGaN of a cladding layer can be thickened, laser oscillation is realizable. When the cladding layer which will consist of AlGaN on a barrier layer on the other hand if a barrier layer is set to GaN is grown up, it is in the inclination which a crack tends to generate in the cladding layer.

[0014] Furthermore, InGaN differs in crystal growth temperature from GaN. For example, in the MOVPE method, GaN grows up InGaN at temperature higher than 800 to making it grow up at 600 degrees C - 800 degrees C. Therefore, if it is going to grow up the barrier layer which consists of GaN after growing up the well layer which consists of InGaN, it is necessary to raise growth temperature. If growth temperature is raised, since the InGaN well layer grown up previously will decompose, it is difficult to obtain a crystalline good well layer. Furthermore, if there is no thickness of a well layer and the dozens of A well layer of a thin film decomposes it, it will become difficult to produce MQW. To it, by this invention, since a barrier layer is also InGaN, a well layer and a barrier layer can grow at

the same temperature. Therefore, since the well layer formed previously does not decompose, crystalline good MQW can be formed.

[0015]

[Example] the following and MOVPE -- although how to create LD component by law is described -- the light emitting device of this invention -- MOVPE -- it can be made to be able to grow up not only using law but using the vapor growth of the nitride semi-conductor with which others, such as MBE and HDVPE, are known, and can apply not only to LD but to LED.

[0016] [Example 1] After installing the often washed silicon on sapphire 1 (0001st page) in the reaction container of MOVPE equipment, ammonia was used for material gas with TMG (trimethylgallium), and the buffer layer 2 which consists of GaN on the surface of silicon on sapphire at the temperature of 500 degrees C was grown up by 200A thickness.

[0017] It is also possible for this buffer layer to have the operation which eases the grid mismatching of a substrate and a nitride semi-conductor, and to grow up AlN, AlGaN, etc. into others. Moreover, the substrate known from the former which consists of single crystals other than sapphire, such as the 111st page (MgAl 2O4) of a spinel, and SiC, MgO, Si, ZnO, is used for a substrate. Although it is known that the crystallinity of n mold nitride semi-conductor grown up on a substrate by growing up this buffer layer will become good, a buffer layer may not grow according to the class of the growth approach and substrate etc.

[0018] Then, temperature was raised to 1050 degrees C, SiH4 (silane) gas was used for material gas as TMG, ammonia, and a donor impurity, and n mold contact layer 3 which consists of an Si dope GaN was grown up by 4-micrometer thickness. By setting n mold contact layer 3 to GaN, a layer with high carrier concentration is obtained and an electrode material and desirable ohmic contact are acquired.

[0019] Next, temperature was lowered to 750 degrees C, silane gas was used for material gas at TMG, TMI (trimethylindium), ammonia, and impurity gas, and first n type layer 4 which consists of Si dope In0.1Ga0.9N was grown up by 500A thickness.

[0020] It becomes possible the nitride semi-conductor of n mold containing In, and by making it grow up by InGaN preferably to grow up the nitride semi-conductor containing aluminum grown up into a degree of this first n type layer 4 with a thick film. In the case

of LD, it is necessary to grow up an optical confinement layer, a lightguide layer, and the becoming layer by thickness 0.1 micrometers or more. Although component production was difficult in the former since the crack went into AlGaN grown up later when AlGaN of a direct thick film was grown up on GaN and an AlGaN layer, first n type layer acts as a buffer layer. That is, it can prevent that a crack goes into the nitride semi-conductor layer containing aluminum which this layer turns into a buffer layer and is grown up into a degree. And even if it grows up the nitride semi-conductor layer containing aluminum grown up into a degree with a thick film, it can grow up with sufficient membraneous quality. In addition, as for first n type layer, it is desirable to make it grow up by thickness (100A or more and 0.5 micrometers or less). If thinner than 100A, it will be hard to act as a buffer layer as mentioned above, and when thicker than 0.5 micrometers, it is in the inclination for the crystal itself to be discolored in black. In addition, this first n type layer 4 is also omissible.

[0021] Next, temperature was made into 1050 degrees C, silane gas was used for material gas at TEG, TMA (trimethylaluminum), ammonia, and impurity gas, and second n type layer 5 which consists of Si dope n mold aluminum0.3Ga0.7N was grown up by 0.5-micrometer thickness. It is desirable for this second n type layer to act as an optical confinement layer in the case of LD, and to make it usually grow up by 0.1 micrometers - 1 micrometer thickness.

[0022] Then, silane gas was used for material gas at TMG, ammonia, and impurity gas, and third n type layer 6 which consists of an Si dope n mold GaN was grown up by 500A thickness. It enables this third n type layer 6 to make the following barrier layer into quantum well structure by also being able to make it grow up with n mold nitride semi-conductor which it is desirable to act as a lightguide layer in the case of LD, and to make it usually grow up by 100A - 1 micrometer thickness, and contains In(s) other than GaN, such as InGaN, and being referred to especially as InGaN and GaN.

[0023] Next, TMG, TMI, and ammonia were used for material gas, and the barrier layer 7 was grown up. A barrier layer 7 holds temperature at 750 degrees C, and grows up the well layer which consists of non dope In0.2Ga0.8N first by 25A thickness. Next, the barrier layer which consists of non dope In0.01Ga0.95N at the same temperature only by changing

the mole ratio of TMI is grown up by 50A thickness. This actuation was repeated 13 times and the barrier layer 7 which a well layer is finally grown up and consists of multiplex quantum well structure of the thickness of the 0.1 micrometers of the total thickness was grown up. Since a well layer and a barrier layer deform elastically, a crystal defect decreases and the output of a component improves by leaps and bounds when the thickness with a desirable well layer grows by 100A or less and a barrier layer grows by thickness 150A or less, laser oscillation becomes possible. If constituting from GaN, InGaN, etc. is desirable as for the nitride semi-conductor with which a well layer contains InGaN(s), such as InGaN, and a barrier layer and it makes it InGaN also with a well layer and a barrier layer especially, since growth temperature can hold them uniformly, they are very more desirable still on industrial engineering.

[0024] First p type layer 8 which makes temperature 1050 degrees C and consists of Mg dope p mold aluminum0.2Ga0.8N, using Cp2Mg (magnesium cyclopentadienyl) as TMG, TMA, ammonia, and a source of acceptor impurity was grown up by 100A thickness after barrier layer 7 growth. The radiant power output of this p type layer [first] 8 improves by growing up 1 micrometer or less of first p type layer 8 which consists of a p mold nitride semi-conductor which there is an operation as a cap layer which prevents that the barrier layer which consists of InGaN by making it grow up by thickness 0.1 micrometers or less still more preferably decomposes, and contains aluminum on a barrier layer. Moreover, although p mold nitride semi-conductor layer is obtained by doping while growing up acceptor impurity, such as Zn, Mg, Cd, calcium, Be, and C, p mold property that Mg is the most desirable is shown also in it. Furthermore, after doping acceptor impurity, if annealing 400 degrees C or more is performed in an inert gas ambient atmosphere, still more desirable p mold will be obtained.

[0025] Next, second p type layer 9 which consists of a Mg dope p mold GaN using TMG, ammonia, and Cp2Mg was grown up by 500A thickness, holding temperature at 1050 degrees C. In the case of LD, this second p type layer 9 acts as a lightguide layer, it is desirable to make it usually grow up by 100A - 1 micrometer thickness, it can also be made to be able to grow up with p mold nitride semi-conductor containing In(s) other than GaN, such as InGaN, and third p type layer 10 containing the following aluminum can be grown

up with sufficient crystallinity by being referred to especially as InGaN and GaN.

[0026] Then, third p type layer 10 which consists of Mg dope aluminum0.3Ga0.7N using TMG, TMA, ammonia, and Cp2Mg was grown up by 0.5-micrometer thickness. As for this third p type layer 10, it is desirable to act as an optical confinement layer in the case of LD, and to make it grow up by 0.1 micrometers - 1 micrometer thickness, and it acts as an optical confinement layer preferably by considering as p mold nitride semi-conductor containing aluminum like AlGaN.

[0027] Then, p mold contact layer 11 which consists of a Mg dope p mold GaN was grown up by 0.5-micrometer thickness using TMG, ammonia, and Cp2Mg. If this p mold contact layer is set to GaN containing Mg, p type layer with the highest carrier concentration will be obtained, and the ingredient of a positive electrode and good ohmic contact will be acquired.

[0028] The wafer which carried out the laminating of the nitride semi-conductor as mentioned above is picked out from a reaction container. n mold contact layer 3 which performed selective etching from p mold contact layer 11 of the maximum upper layer, was made to expose the front face of n mold contact layer 3 as shown in drawing 1 , and was exposed, After forming a stripe-like electrode in the front face of p mold contact layer 11, respectively, from the direction which intersects perpendicularly with a stripe-like electrode, it etched further, the perpendicular etching end face was formed, the reflecting mirror was formed in the etching side according to the conventional method, and it considered as the resonance side. The sectional view of a laser component seen from the resonance side side is a sectional view shown in drawing 1 . Since the laminating of the crystal which was very excellent had been carried out when this laser component was installed in the heat sink and it was referred to as LD, in ordinary temperature, threshold current density 4.0 kA/cm2 showed with the luminescence wavelength of 410nm, and a half-value width [of 2nm] laser oscillation.

[0029]

[Effect of the Invention] As explained above, since the light emitting device of this invention had the barrier layer of MQW which carried out the laminating of the well layer which consists of a nitride semi-conductor containing In, and the barrier layer which

consists of a nitride semi-conductor containing In, its output of a light emitting device improved and it has realized the laser diode. This is because the good barrier layer of membraneous quality can be growing. Thus, by short wavelength LD having been realizable by this invention, the capacity as the write-in light source and the readout light source improves by leaps and bounds compared with the former, and the utility value on the industry has it. [very large]

[Brief Description of the Drawings]

[Drawing 1] The type section Fig. showing the structure of LD concerning one example of this invention.

[Drawing 2] Drawing showing the relation of the well layer of the barrier layer of a component and radiant power output concerning one example of this invention.

[Drawing 3] Drawing showing the relation of the barrier layer of the barrier layer of a component and radiant power output concerning one example of this invention.

[Description of Notations]

1 ... Substrate

2 ... GaN buffer layer

3 ... n mold GaN (n mold contact layer)

4 ... n mold InGaN (first n type layer)

5 ... n mold AlGaN (second n type layer)

6 ... n mold GaN (third n type layer)

7 ... Barrier layer

8 ... p mold AlGaN (first p type layer)

9 ... p mold GaN (second p type layer)

10 ... p mold AlGaN (third p type layer)

11 ... p mold GaN (p mold contact layer)